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LOSS OF LIFE AMONG WEARERS OF OXYGEN BREATHING APPARATUS

BY

G. W. GROVE

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..S OF LIFE AMONG WEARERS OF OXYGEN BREATHING APPARATUS[1]

By G. W. Grove[2]

INTRODUCTION

The wearing of self-contained oxygen breathing apparatus, although ..atively safe if proper precautions are taken, is dangerous if defective ..paratus is worn, if men with inadequate training, experience, and physi.. requirements are used, or if improper procedure is followed. This is ..rned by the fact that at least 26 men are known to have lost their lives ..e wearing oxygen breathing apparatus since its introduction in this ..ntry about 35 years ago.

Self-contained oxygen breathing apparatus, commonly called "mine ..cue apparatus" and sometimes improperly referred to as "oxygen ..ets," is the only equipment that can be used for respiratory protection ..inst poisonous mine gases, regardless of concentration or against an ..osphere containing little or no oxygen.[3] Apparatus of this type was ..oduced in this country in 1907, and since that time it has been widely ..d in conducting rescue and recovery work after mine fires and ex.. ..sions and in some other work. All oxygen breathing apparatus used in ..is country before 1918 was imported from Europe, and although this ..ipment provided safer, more rapid means of conducting recovery work ..er mine disasters, there were many mechanical deficiencies in the ..paratus which resulted in the death of some of the wearers. This led to ..e research and experimental work by the Bureau of Mines that resulted ..the development and manufacture of more reliable and efficient types ..paratus in this country.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7279."

[2] Supervising engineer, District A, Health and Safety Service, Bureau of Mines, Pittsburgh, Pa.

[3] Forbes, J. J. and Grove G. W., Protection Against Mine Gases: Bureau of Mines, 1937, 52 pp.

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Little or no oxygen breathing apparatus has been imported since 1918, as the types designed, developed, and made in the United States are in all respects equal and in many ways superior to those manufactured in foreign countries.

Before 1912, little attention was paid to instructing and training men in the construction, testing, use, and care of oxygen breathing apparatus, and still less consideration was given to proper procedure in conducting rescue and recovery work. It was not unusual for one, two, three or four men to put on apparatus and make, or attempt to make, explorations ahead of fresh air after mine disasters. Often these men had little or no previous training in wearing the apparatus other than a few oral instructions, and little or no thought was given to the possibility of mechanical failure of the equipment or what might be done for the relief and rescue of apparatus wearers should mechanical failure develop in a poisonous, noxious, or oxygen-depleted atmosphere. Moreover, no limit was placed on the distance apparatus wearers might travel ahead of fresh air, and no effort was made to determine the physical condition of the men previous to the wearing of apparatus.

Under such conditions (which incidentally still prevail in entirely too many instances) it is not strange that men collapsed and lost their lives while wearing oxygen breathing apparatus, but rather it is surprising that greater loss of life has not occurred.

Investigation by the Bureau of Mines of the death of several men who were wearing oxygen breathing apparatus resulted in the adoption in 1921 Mine Rescue Standards.4/ These standards contained requirements for physical condition of apparatus wearers and the procedure to be followed in rescue and recovery operations. The Bureau also issued several handbooks describing in detail the construction, testing, wearing, etc., of oxygen apparatus; the first was published in 1923 and the latest was issued in 1941.5/ No doubt these handbooks also contributed materially to the safe use of such apparatus. Unfortunately necessary precautions are sometimes disregarded, and apparatus men continue to lose their lives.

ACKNOWLEDGMENTS

The assistance of M. J. Ankeny, mining engineer of the Safety Division of the Bureau of Mines, in abstracting material from Bureau of Mines and State reports and in preparing a considerable amount of the material contained in this publication is gratefully acknowledged.

4/ Mine Rescue Standards: Bureau of Mines Tech. Paper 334, 1923, 44

5/ Grove, G. W., Self-Contained Oxygen Breathing Apparatus, A Handbo for Miners: Bureau of Mines, 1941, 234 pp.

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Acknowledgment is also made to S. H. Ash, mining engineer, Bureau of Mines, Washington, D. C., for information and suggestions regarding the accident in the slope of the Pacific Coast Coal Co., to L. L. Naus, mining engineer, Safety Division, Bureau of Mines, Denver, Colo., for obtaining information relative to the occurrence in the Wanamie Colliery; and to Peter McLinden, inspector at large, West Virginia Department of Mines, Fairmont, W. Va., for information in connection with the accident on November 13, 1917, in the Jamison No. 7 mine, Barrackville, W. Va.

CIRCUMSTANCES LEADING TO LOSS OF LIFE

The Bureau of Mines has information showing that from 1911 to 1940, inclusive, 26 men have lost their lives while wearing oxygen breathing apparatus in this country.

Five of the 26 persons killed (1 in 1911, 1 in 1912, 1 in 1913, 1 in 1916, and 1 in 1919) were employees of the Bureau of Mines, 17 were employees of mining companies, and 1 man was not employed by either the Bureau of Mines or in the mining industry.

In 13 instances, 1 man lost his life; in 3 instances, 2 men lost their lives; and in 2 other occurrences, 3 men lost their lives. It is noteworthy that in 1 instance 1 man lost his life and in another 2 men lost their lives while the teams of which they were members were engaged in training maneuvers and not in connection with mine fires or explosions. Also, on still another occasion, 1 man lost his life upon entering a surface gasoline-storage tank.

The persons who lost their lives while wearing oxygen breathing apparatus, together with some surrounding conditions in connection with these fatalities, listed in chronological order, are as follows:

E. A. Sutton

On February 9, 1911, E. A. Sutton, assistant superintendent of the Cokedale mine of the Carbon Coal & Coke Co., Carbondale, Colo., lost his life while wearing a Draeger helmet-type oxygen breathing apparatus after an explosion in this mine in which 17 men were killed. It is believed that this is the first instance in the United States, wherein a person died while wearing oxygen breathing apparatus.

This company was one of the first in Colorado to install oxygen breathing apparatus, but only three apparatus were purchased and available at the time of the explosion. Sutton had worn the apparatus on only two previous occasions, for periods of one-half hour each, and therefore was not thoroughly familiar with its operation.

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Sutton and a superintendent from a neighboring mine each put on an apparatus and left the third at the fresh-air base in reserve. When they had traveled a considerable distance from the fresh-air base, his companion, who was traveling about 150 feet behind Mr. Sutton, saw him struggle with his apparatus and suddenly fall. The companion immediatel returned to fresh air for help.

After considerable delay, two workmen volunteered to go after Sutton without the aid of respiratory protection; when they reached a point within about 100 yards of where he was lying, one collapsed and the other returned to fresh air. Thirty minutes thereafter additional apparatus crews arrived and recovered the bodies of Sutton and the workman. They were treated with a pulmotor for more than an hour, but neither could be revived.

Examination of Sutton's apparatus revealed that one of the potash cartridges had not been connected at the bottom. This permitted the injector to pull in outside air, which presumably contained carbon monoxide.

Joseph E. Evans

On April 7, 1911, Joseph E. Evans, foreman miner of Bureau of Mines rescue car No. 1, lost his life while wearing a Draeger self-contained oxygen breathing apparatus. Evans' death occurred during an exploration trip in the Pancoast colliery of the Price-Pancoast Coal Co., Throop, Pa., after a mine fire in which 72 other persons were killed.

Evans and his crew of three men, consisting of one Bureau of Mine employee and two others, an ex-employee of the Bureau of Mines and one other person, had proceeded about 500 feet ahead of fresh air when Evans experienced some difficulty with his apparatus. After leaving one of the men with Evans and advising them to return to fresh air, the other two men proceeded on the exploration trip, returning to the fresh-air base by a different route. Following a brief rest, Evans and his companion proceeded about 80 feet toward the fresh-air base when Evans fell. His companion first examined the apparatus to see that it was functioning properl then went to look for the other two members of the party. Failing to find them, he proceeded to the fresh-air base and reported that Evans was do Shortly thereafter, the two other men of the party reached the fresh-air base and upon learning that Evans had collapsed, went to where he had fallen. After adjusting Evans' apparatus, they proceeded to the fresh-air base to obtain additional help. Later they returned with help and brought

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him to the fresh-air base on a stretcher. The application of artificial respiration and the use of a pulmotor failed to revive him.

So far as could be determined, no defect existed in the functioning of the apparatus.

John Ferrell

On January 19, 1912, John Ferrell, in charge of a party of three other employees of the Bureau of Mines, entered the No. 2 mine of the Pittsburgh & Eastern Coal Co., Cherry Valley, Pa., to assist with the opening of a fire area that had been sealed on November 14, 1911.

An opening was made in one of the seals, and Ferrell and a coworker, wearing Draeger helmet-type apparatus, entered through a stopping to make an exploration to the seat of the fire, a distance of about 215 feet. Within 5 minutes after entering, Ferrell's companion indicated that he was having difficulty with his apparatus and wished to return to fresh air. Ferrell directed him to do so, indicating that he would follow. When the distressed man reached the outside of the stopping he discovered that Ferrell had not followed him, as he expected. Shortly after he reached the outside of the stopping he heard three raps on the trolley wire within the sealed area, indicating that Ferrell may have been in distress. A second companion of Ferrell then entered the sealed area, wearing a Draeger mouthpiece-type apparatus, in an effort to locate him. Returning in about five minutes, exhausted, he collapsed at the opening of the stopping, was pulled through to the outside, and revived by artificial respiration. It later was determined that this man found Ferrell at the face of a room, lying on his back with his helmet off; but in trying to get Ferrell out through a narrow space between the rib and a car the would-be rescuer's nose clip was dislodged, and after inhaling some of the bad air he was compelled to return to the fresh air without Ferrell. A third companion, wearing a helmet-type apparatus, made three attempts to locate Ferrell but each time returned to the opening exhausted. Later in the night additional men from the Bureau of Mines arrived from Pittsburgh and recovered the body of Ferrell. The oxygen supply of his apparatus was found to be completely exhausted, but the pneumatic face cushion of the helmet, although not on his face, was still inflated. A bruise on his forehead indicated that he had fallen and dislodged his helmet.

Subsequent tests on the apparatus worn by Ferrell at the time of his death revealed that the apparatus was defective to the extent that outside air could get into it. Whether this defect occurred before the apparatus was taken to the mine, after it was taken into the mine, or at the time of the accident could not be determined. The apparatus worn by the other two men were also found to be defective.

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William McColligan

On April 23, 1913, William McColligan, a member of a rescue crew of the Pittsburgh Coal Co., died while making an exploration trip ahead of fresh air after an explosion in the Cincinnati mine, operated by this company, in which 97 men were killed.

McColligan and his crew of five men were equipped with Draeger helmet-type apparatus, which had been carried into the mine by a reserve crew, so that the apparatus men would be in good condition for advance work. After exploring a series of entries and starting back toward the fresh-air base McColligan collapsed. The other crew members tried to drag him to fresh air, but two of them went down in the attempt; however, they were able to get to their feet and stumble out to the fresh-air base. Several men from the fresh-air base tried to reach McColligan without the use of apparatus but were unable to do so, and his body was not recovered until after fresh air was directed into the place where he collapsed. Two physicians then worked on him for over an hour, using artificial respiration, electric batteries, and a pulmotor, without response.

The apparatus worn by McColligan was examined by two representatives of the Bureau of Mines, who found that the flexible tube inserted in the thimble, directly over the injector, had been pulled out of its socket, this permitting the toxic mine atmosphere to enter the apparatus.

Edward Evans

On September 30, 1913, Edward Evans, an employee of the Bureau of Mines, lost his life during mine rescue maneuvers at a mine of the Union Pacific Coal Co., Rock Springs, Wyo. Evans, wearing a mouthpiece type Draeger oxygen breathing apparatus, was making a training trip under ground under oxygen with a complete crew when he collapsed. He was promptly brought to the surface, and an attempt was made to resuscitate him with a pulmotor. A doctor, arriving shortly thereafter, indicated that heart action had ceased. The atmosphere in which the maneuvers were being conducted was irrespirable because of blackdamp.

Despite the fact that Evans apparently was in robust health and had passed several physical examinations in connection with his mine rescue work previous to his death, an autopsy revealed defective heart and kidney conditions. Reports concerning Evans' death indicate that he had spent his entire life in low-altitude sections of the United States and that his work at Rock Springs, where the altitude exceeds 6,000 feet, may have been a contributory cause of his collapse and death. Although the reports indicated that Evans passed the required physical examination in Pennsylvania, before being engaged in the wearing of breathing apparatus, there was nothing

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show that he was given a physical examination before wearing apparatus in high altitudes. A physical examination given previous to entering the mine, in this instance, might have revealed the defective heart condition. So far as could be determined, the apparatus worn by Evans was not defective.

At the time of this accident, the authorities were beginning to realize that there was much need for improving breathing apparatus. Tests conducted previously on the Draeger apparatus in England indicated that the regenerator of the apparatus could not absorb all of the carbon dioxide exhaled by the wearer while performing strenuous work.

James Laird and B. Poyser

On October 22, 1913, James Laird and B. Poyser, members of a rescue crew of five men of the Stag Canon Fuel Co., lost their lives while on an exploration trip in the No. 2 mine of the same company at Dawson, N. Mex., following an explosion that killed 256 men. The crew, equipped with Draeger helmet-type apparatus, had been instructed that if they came to heavy falls they were not to attempt to go over them; so, when a heavy fall was encountered the leader of the crew, in accordance with his instructions, told the others they had better return to the fresh-air base. However, two members of the crew disregarded these instructions and pushed forward over the fall; they were followed by the others, and eventually, the crew reached the face of the entries, a distance of about 2,000 feet from the fresh-air base. Soon after examining the faces of the entries and before starting back toward the fresh-air base, Laird collapsed. Poyser, in attempting to revive Laird, also collapsed. The leader of the crew stayed with the men, attempting to revive them, while the remaining two crew members returned to the fresh-air base. When the crew leader realized that his oxygen supply was getting low, he also returned to the fresh-air base. The accident disorganized the rescue personnel so badly that it was impossible to assemble a crew of volunteers to recover the bodies until the next morning.

Gomer Phillips

On May 25, 1915, Gomer Phillips, an instructor in charge of first aid and mine rescue for the Cambria Steel Co., lost his life 400 feet beyond the fresh-air base while on an exploration trip after an explosion in the No. 1 mine of the Smokeless Coal Co., Johnstown, Pa., in which eight persons were killed.

A crew consisting of Phillips and three other mine rescue men of the same company, wearing Fleuss oxygen breathing apparatus, left the

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fresh-air base to make a contemplated exploration trip of about 1,400 feet. After advancing about 500 feet, Phillips complained that he did not feel well but was persuaded by a member of the crew to continue on the exploration. After traveling some distance, Phillips suddenly turned, broke away from the crew, and started running toward the fresh-air base. He ran about 30 feet and fell forward on his face. The other three men of the crew followed him, picked him up, and carried him about 60 feet, but stopped because of exhaustion, and two of them fell down. The remaining crew member succeeded in reaching the fresh-air base and reported that the other three men were down. Two other men, without apparatus, attempted to reach Phillips and the other two members of the rescue crew, but this effort failed. Canvas brattices were then erected in the crosscuts, and fresh air was directed toward the point where the men had collapsed. One of the men was met crawling toward the fresh-air base on his hands and knees. Phillips and his companion were found where they had fallen. They were carried or dragged back to the fresh-air base, a distance of about 350 feet. On reaching the fresh-air base artificial respiration was applied, and Phillips' companion was revived in about one-half hour. However, continued artificial respiration and the use of a pulmotor for over an hour failed to revive Phillips. Careful examination of the equipment worn by these men failed to reveal any defects.

Thomas Hendrickson[6/]

On September 17, 1915, Thomas Hendrickson, a foreman of the International Exploration Co., lost his life while wearing a Draeger 2-hour oxygen breathing apparatus during an exploration in the Alta-Quincy tunnel near Salt Lake City, Utah, leased by the Albion Mining Co.

According to newspaper accounts, the drift in which Hendrickson lost his life became filled with carbon dioxide gas, and a day or two before the accident the owners of the Albion mine sent to the Salt Lake City Fire Department to obtain oxygen breathing apparatus, and a captain of the department took two apparatus to the mine.

On arrival at the mine, Hendrickson (who claimed he had wide experience in wearing oxygen breathing apparatus), with a Draeger helmet-type apparatus, and the fire-department captain (who had no experience in wearing apparatus), with a Draeger mouthpiece-type apparatus, accompanied by a group of other men, entered the tunnel. After traveling some distance their flame lights went out, and they retreated a short distance to where the lights would burn. The two men with apparatus then turned on the oxygen and proceeded with the exploration, leaving the other men without apparatus at that point.

6/ Hendrickson's first name also appears as James and Jack in newspaper clippings, either of which may be correct, instead of Thomas.

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After traveling a distance of about 2,000 feet, Hendrickson experienced difficulty with his apparatus, and after retreating about 200 feet, assisted by the other man, he collapsed. In falling, he pulled the mouthpiece and nose clip off the face of his companion, who then tried to break a compressed-air line to get air. Finding himself becoming exhausted the fire-department captain was compelled to leave Hendrickson and retreat toward fresh air.

He was later rescued, as he crawled on his hands and knees toward the fresh-air base, by two or three of the men who had been left at the fresh-air base. Several other men at the fresh-air base had previously been overcome in an effort to reach him. After recovering he returned four times to break the compressed-air line, and this later permitted the recovery of Hendrickson's body.

Lewis M. Jones

On October 20, 1916, Lewis M. Jones, a mining engineer of the Bureau of Mines and in charge of rescue and recovery work for the Bureau, lost his life while wearing a Fleuss oxygen breathing apparatus on an exploration trip following an explosion in the No. 7 mine of the Jamison Coal & Coke Co., Barrackville, W. Va., in which 10 men were killed.

The exploration party, consisting of Jones, as the rear man, three other Bureau of Mines apparatus men, and one local apparatus man, left the fresh-air base pulling a lifeline and carrying six 100-foot coils of clothesline to be attached to the end of the lifeline when it was extended to its full 1,000 feet. Another Bureau of Mines man and a local man, both equipped with oxygen breathing apparatus, and a third man not so equipped were left as a reserve crew at the fresh-air base. When the full length of the lifeline was paid out, the coils of clothesline were attached, one after another, until all were fastened together. The party then proceeded 1,000 feet or more beyond the end of the lifeline, a total distance of about 3,000 feet, and had almost reached their objective when they stopped for a short rest and to read their apparatus gages.

The trip up to this point had been made at a moderate pace, under good conditions of travel, with ample height and few falls. When travel was resumed and after traveling a short distance, the man next to Jones noticed that he was not following the crew. This man immediately returned to Jones and found him leaning against the rib. As he reached him Jones' knees gave way and he started to fall. The crew member placed his hand on Jones' chest, pushed him against the rib to prevent him from falling and examined his apparatus. Finding the main oxygen valve of Jones' apparatus closed the crew member opened it and the bypass valve. On receiving the fresh oxygen Jones seemed to rally for a short time but soon

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collapsed. He was then placed on a stretcher by the rest of the crew, they having joined Jones and his companion, and it was determined that h mouthpiece and nose clip were in place. He was breathing heavily, but t apparatus was apparently working properly. The party then started out; after carrying Jones about 1,300 feet outby, one of the men became exhausted and they had to stop. When they stopped, they gave Jones extra oxygen through the bypass. Two of the party then started for the fresh-air base for help, leaving the two others with Jones. Fifteen or twenty minutes thereafter the two men who were with Jones decided that they to would be forced to leave him because their oxygen was getting low, and it was feared that the other two men might not have reached the fresh-air base. When these men left Jones, it was observed that he was still breathing heavily.

Both parties reached the fresh-air base safely, but considerable time was consumed in organizing a relief crew to go in and get Jones. Finally a party of three men wearing breathing apparatus, who were met on the way out by a fourth man wearing apparatus, went in and brought Jones out. In their haste to get Jones to fresh air, they did not take the time to determine whether or not he was still breathing. Arriving at the fresh-air base, artificial respiration was started immediately, and oxyg was administered by means of a resuscitator. Meanwhile, a doctor arri and upon examining Jones failed to detect any heart action. When the oxy supply of the resuscitator became exhausted a lung motor was used for a while without results. The doctor finally decided that Jones was dead an discouraged further efforts at resuscitation.

A period of 2 hours and 20 minutes had elapsed between the time the original crew left the fresh-air base and the time Jones' body was brought back to the fresh-air base.

Subsequent examination and wearing of the apparatus worn by Jone disclosed no defects, with the exception of a small crack or break in the base of the rubber mouthpiece where it joined the outer flap; however, t may have been caused after the apparatus was removed from Jones, as according to some of the crew members, little attention was paid to it, and possibly several men walked on the mouthpiece during the efforts to revive him.

The reason why the main oxygen valve on Jones' apparatus should be found closed by the man who first reached him can readily be understood when it is considered that the gage valve on a Fleuss apparatus could and often was placed directly over the main closing valve when the

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reducing valve was being attached to the oxygen bottle. Because the wearers of the apparatus were instructed to keep the gage valve closed excepting when actually reading the gage, this sometimes resulted in the wearer closing the main oxygen-supply valve instead of the gage valve. When this occurred the oxygen in the apparatus would be consumed in a short time; and the wearer, in his efforts to obtain air, might draw outside air containing carbon monoxide into the apparatus. This may have been what happened to Jones, and the carbon monoxide drawn into the apparatus resulted in his death.

Walter Kerr

On May 6, 1917, Walter Kerr, a member of a mine rescue team of the Colorado Fuel & Iron Co., died wearing a Draeger 2-hour oxygen breathing apparatus, while helping to recover bodies, after an explosion in the Hastings mine of the Victor American Fuel Co., Hastings, Colo., in which 121 men were killed.

Kerr, while assisting other members of an apparatus crew in carrying a body, suddenly left his crew and was later found dead in a crosscut at the face of a pair of entries. Detailed information concerning this occurrence is not available; however, while there apparently was some idea that the apparatus worn by Kerr might have been defective, an autopsy disclosed that he had a defective heart, that overexertion caused heart failure under the strain of wearing apparatus, and that a defective heart condition existed previous to his death.

This case again emphasizes the need for a careful physical examination before a man wears an apparatus under actual mine conditions.

Samuel T. McMahon and Bryce Warren

On November 13, 1917, Samuel T. McMahon and Bryce Warren lost their lives while wearing Fleuss oxygen breathing apparatus in a sealed fire area in the No. 7 mine of the Jamison Coal & Coke Co., Barrackville, W. Va.

An explosion occurred in this mine on October 19, 1916. The explosion resulted in a serious fire that required sealing of the north section of the mine. (Lewis M. Jones, an employee of the Bureau of Mines, lost his life during an exploration trip after the explosion.) About a month after the fire was sealed in the north section of the mine, where an apparatus crew was making an exploration in the fire area, a local gas explosion occurred. The apparatus crew and about 35 other men, who were cleaning up the south section, immediately went to the surface. A few

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minutes after the men had reached the surface, a terrific explosion occurred, following which the mine was again sealed.

The services of McMahon, who at the time of the initial explosion was employed as district mine inspector by the West Virginia Departmen of Mines, was obtained to direct recovery operations. The work was beg about January 27, 1917, and to guard against the entrance of air into the sealed area, air locks were being used in conducting the recovery work. The air locks were being erected about 900 feet apart, and on the day of the accident McMahon, Warren, and two other men wearing apparatus had been building stoppings to seal off openings in a 900-foot section. A lifeline was not being used, and no reserve crew was at the fresh-air bas About 3:00 p.m., one of the crew stated that he was feeling bad, and McMahon sent him and another man to the fresh-air base outside the air lock, stating that he and Warren would follow soon. At this time all of th apparatus contained about a 40-minute oxygen supply. After waiting abo 45 minutes and hearing nothing from McMahon and Warren, the two men at the fresh-air base became alarmed. They entered the air lock and on opening the door of the second stopping of the air lock a light was seen on the floor about 200 feet inby. The two men, under oxygen, proceeded to the light and found McMahon unconscious, nose clip removed, hand on bypass valve, and oxygen supply exhausted. The two men then, instead of attempting to rescue McMahon, proceeded to the surface to obtain assistance; as a result, McMahon's body was not recovered until about 5:00 p. m., or about 1 hour and 20 minutes after being discovered. Artificial respiration was used for some time, but McMahon could not be revived.

Warren's body was located and recovered about 9:45 p. m., or approximately 6 hours after McMahon's body was discovered. It was found a few feet inby the stopping at the extreme end of the 900-foot section of the main air lock; the nose clip was off and the bypass valve of th apparatus was open. This stopping was equipped with a slide door, and there were indications that McMahon had endeavored to assist Warren through this door. Evidently McMahon and Warren had explored some distance inby the stopping at the end of the air lock, and ran out of oxyge before they could reach fresh air. The apparatus worn by McMahon and Warren had, so far as known, operated perfectly for about 1 hour and 20 minutes before the accident or up to the time the two other men left them.

Both sets of apparatus were tested after the accident, and no defec were found. It is believed that Warren's oxygen supply became prematu exhausted owing to excessive use of the bypass valve and that McMahon, attempting to assist Warren, also used oxygen faster than he expected, thereby depleting his supply. However, in view of the limited oxygen

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supply at the time that the two other men left them, they should not have attempted an exploration and should have returned to fresh air while they still had an ample supply of oxygen.

David Murphy

On February 26, 1918, David Murphy, an experienced mine rescue volunteer from Dawson, N. Mex., lost his life while wearing a Fleuss mouthpiece-type oxygen breathing apparatus during an exploration trip in the Government mine of the Carthage Fuel Co., Carthage, N. Mex.

The crew of five men that made the exploration trip, during which Murphy lost his life, was under the charge of a representative of the Bureau of Mines, who later lost his own life while wearing oxygen breathing apparatus, in a gasoline tank, the following year.

All members of the crew were given careful physical examinations by the surgeon attached to the Bureau of Mines Rescue Car, but Murphy was not familiar with the operation of the Fleuss apparatus, having been previously trained in using the Draeger apparatus.

Before entering the slope, the portal of which was the fresh-air base, the team captain inspected all apparatus in the party and saw that each machine was working properly. He also stopped at intervals on the way into the slope to ask if each man were all right. After reaching their objective, about 600 feet from the portal, it was decided to return to the surface. About 300 feet from the portal, Murphy indicated that he was in distress. The team captain adjusted his mouthpiece and nose clip, gave him more oxygen with the bypass, and placed him on a stretcher. At this time another member of the team exhibited signs of distress and sat down on the floor. Two of the team members carried him some distance up the slope, but were unable to carry him out because of exhaustion, and they decided to go to the surface for help.

Meanwhile, the team captain remained with Murphy, adjusted his mouthpiece, tied it firmly in place, adjusted his nose clip, and turned him over on his face. He then attempted to carry him but was unable to do so. The attempt to carry Murphy exhausted the team captain to the extent that he was able to reach the surface only with extreme difficulty.

When the team captain reached the surface, and it was determined that there were still two men in the slope, it was decided to remove the fan from the mouth of the slope and drop a trip to where the men were working on the roadway. After reconditioning the apparatus, the trip, consisting the team captain and three others, was lowered down the slope to where the first man was down. It was noticed that his apparatus was still

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functioning and that he had 30 minutes of oxygen remaining. He was put in the car and taken to the surface immediately. The trip was then lower to where Murphy was lying. It was observed that he had turned over on his back, the mouthpiece was partly out of his mouth, and his nose clip wa off. Fifteen minutes oxygen supply was still in the oxygen cylinder. Murphy was placed in the trip and brought out at once. Stimulants, artificial respiration, and oxygen inhalations were given, but he failed to revive. Breathing was restored to his companion in about 15 minutes, an he regained consciousness in about an hour.

A lifeline was used by this crew in making the exploration, but a reserve crew was not maintained at the fresh-air base. The apparatus worn by Murphy and his companion was worn again 2 days later under actual working conditions, and no difficulty was experienced. It is report that the team captain had some difficulty in controlling Murphy and his companion while they were on the exploration trip, and that they talked to each other incessantly before the accident. It is surmised that each of them inhaled carbon monoxide around their mouthpieces while talking.

James S. Cunningham

On August 25, 1919, James S. Cunningham, foreman miner of Burea of Mines rescue car No. 2, died while wearing a Salvus 1/2-hour apparatu in a gasoline storage tank of the Sinclair Oil & Refining Co., Trinidad, Co

The gasoline tank had a capacity of 12,000 gallons and was about 18 feet high. There was a manhole at the top and a steel ladder on the inside leading from the manhole to the bottom of the tank. The gasoline in the tank at the time of the accident was about 7 inches deep.

Cunningham tested and checked the apparatus carefully on the rescu car and proceeded directly to the place where he had volunteered to enter the gasoline tank to make a pipe connection. He entered the tank through the manhole, went down the ladder to the bottom, and then returned to the top to make sure his apparatus was functioning properly. Two employees the oil company stayed at the manhole at the top of the tank. It is reporte that a suggestion was made that a lifeline be used, but since it was not immediately available, Cunningham decided to enter the tank without it. After determining that his apparatus was functioning properly, he went down the ladder the second time and found the place where the connection was to be made. Immediately thereafter, and before starting to work, he exhibited signs of confusion or distress, then fell over into the gasoline, lying with his head submerged in the gasoline. His body was later recove with a grappling hook.

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The apparatus was sent to the Pittsburgh Experimental Station of the Bureau of Mines for inspection and testing; it was found that the rubber lining of the breathing bag had deteriorated, with the sides adhering together. The inside rubber was found to be gummy, and the rubber lining on the outside of the fabric had been almost completely dissolved. Tests were also conducted on a similar apparatus, a duplicate in every way to the one Cunningham used, by subjecting it to gasoline in both vapor and liquid forms. The conclusion from the tests was as follows: "The experiments show that gasoline and also gasoline vapor in higher concentrations can penetrate the thin rubberized bags such as have been used on the 2-hour oxygen breathing apparatus ....."

This accident led to development of heavy rubberized breathing bags for oxygen apparatus that are now used on some of the modern mine rescue equipment. Subsequent tests on heavy bags revealed that high concentrations of gasoline vapors will, in time, penetrate even them. The Bureau therefore, recommended that the heaviest-type breathing bags should not be used in gasoline vapors longer than 2 hours in all, after which the bag should be discarded or thoroughly soaked and washed with water and aired out before reuse. It is also recommended, when it is necessary to enter a place containing gasoline vapors while wearing an oxygen breathing apparatus, that a line or safety belt be employed, and that the apparatus man or men be watched closely so that they can be withdrawn immediately in case of distress.

Henry DeWinter, Hugh Hughes, and James Hudson

On July 10, 1920, Henry DeWinter, Hugh Hughes, and James Hudson lost their lives while wearing oxygen breathing apparatus in an abandoned slope of the Black Diamond No. 2 mine of the Pacific Coast Coal Co., Black Diamond, Wash. Hughes and DeWinter, wearing Draeger apparatus, were members of the Black Diamond mine rescue team which had gone down the slope to measure the height of the water in the slope as part of their mine rescue training practice. Hudson, wearing Gibbs apparatus, lost his life while assisting with the recovery of the bodies of Hughes and DeWinter.

The crew left the slope portal, which was the fresh-air base, without a reserve crew present but with a man at the portal to pay out the lifeline. The pitch of the first 500 feet of the slope was about 25°, while the balance of the slope was 35°. The crew descended about 200 feet when the flame of the safety lamp they were carrying was almost extinguished by blackdamp. They retreated a short distance, hung the lamp on a timber, and descended to the water, which was about 1,400 feet from the portal. After reaching the water, the crew members took a short rest, read their gages, and started to return. They had proceeded a short distance when DeWinter

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collapsed. The team captain opened the bypass of DeWinter's machine, but there was no flow of oxygen. The four remaining members of the crew had carried him 30 feet, when Hughes collapsed. Realizing that it would be impossible to carry both men up the slope the remainder of the crew decided to go to the surface for help. One of the men reached the surface in good condition, another collapsed when he reached the fres air, and the third collapsed before he reached the portal and had to be assisted by the man that had been left at the fresh-air base.

A call was sent out for assistance, which was received by a Bureau of Mines employee who had just finished training a team at Burnett, a town 18 miles away. Taking four members of the Burnett team with him, the Bureau man drove to the mine immediately and organized a crew to enter the slope and a crew to stay in reserve at the portal. The advance crew entered the slope and brought out the body of Hughes. Hudson and four other men, wearing apparatus, descended the slope to recover De-Winter's body. This crew had brought DeWinter's body a short distance, when one of their members was found to be in distress, complaining of not getting enough oxygen, and later he went to the surface. It is general supposed that in using the bypass valve he had turned off the main bottle valve (perhaps a similar condition as described in the case of Lewis M. Jones, previously described). When this man found that his apparatus wa again working properly, he started to rush up the slope, deserting the cr On his trip out, he was met by another rescue crew coming down the slo Two members of this crew assisted him until he was within 100 feet of t fresh-air base, when he collapsed. Men at the fresh-air base brought hi to the surface, where he was revived. He had worn a Bureau of Mines Fleuss apparatus, and it is believed that in his rush to get outside the ox applied by the reducing valve was insufficient, causing him to gasp and inhale some of the mine atmosphere.

Soon after this man left the crew, Hudson became distressed. He assisted a short distance by four other crew members, but finding it im-possible to carry him they left one man with him and went for assistance Soon thereafter the relief crew arrived and tied a rope around this body. The crew at the fresh-air base pulled him to the surface while the rescu crew guided his body. No reason is given for Hudson's collapse other th excitement or fright. It is known that when he collapsed his apparatus w apparently working perfectly and was adjusted properly. His apparatus became somewhat deranged while he was being dragged out of the mine, and he probably breathed some of the mine air. He was given artificial respiration for 1 hour and 27 minutes without results. Hudson had been wearing a Gibbs apparatus, which was tested later and found to be in per fect working condition; moreover, the same apparatus was worn again th same day, and no trouble was experienced with it.

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When Hudson was brought out of the mine, it was believed certain that DeWinter was dead, and since the rescue crews were exhausted a second call was sent out for additional help. Rescue teams from Carbondale, Hyde, Bayne, and New Castle, Wash., responded. These apparatus men, in groups of three, were stationed at 200-foot intervals in the slope. DeWinter's body was lashed to a sled, which was pulled with a rope by men at the fresh-air base. The crew that lashed DeWinter's body to the sled guided it for a distance of 200 feet, where the next crew took over for the next 200 feet, and so on until the body reached the surface. Approximately 12 hours had elapsed between the time DeWinter entered the slope and the time his body reached the surface.

Albert Gilmore

On December 31, 1921, Albert Gilmore, a section foreman, lost his life in the No. 1 mine of the Ellsworth Collieries Co., Ellsworth, Pa., while wearing a Gibbs 2-hour oxygen breathing apparatus following a local mine explosion.

The apparatus crew, of which Gilmore was the leader, had been exploring two crosscuts ahead of the ventilation as the air was being advanced in the recovery of the mine. One of the five oxygen breathing apparatus belonging to the crew had been damaged in transportation, and another developed a leak while in service, leaving only three sets of apparatus available for use. The work was being conducted by sending the three available apparatus men ahead in such a formation that one man would stay far enough in the rear to be out of danger with the thought that he could render assistance if the two men ahead encountered any trouble. A lifeline was not used, and there was no reserve crew at the fresh-air base. After four advance examinations had been made in this way, the crew started on a trip, but this time all three went together. Instead of advancing about 200 feet the crew had traveled about 600 feet ahead of the fresh-air base when Gilmore collapsed. About 10 minutes after the crew left the fresh-air base one of the members came running back and collapsed upon his arrival at fresh air. His apparatus was taken off and recharged, but it was found that the apparatus was damaged so that it could not be used. The other member of the crew ran down the return airway and reached fresh air by coming through one of the canvas stoppings. His apparatus was also in such condition that it could not be used. The atmosphere ahead was so filled with afterdamp that it was found impossible to reach Gilmore without respiratory protection. Therefore, it was decided to advance the air to where Gilmore had fallen without further exploration. Owing to the distance supplies had to be carried, 2 hours were consumed in reaching the body of Gilmore. He was given artificial respiration and oxygen inhalations for 2-1/2 hours in the presence of a physician but failed to respond.

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When he started the trip there were about 95 atmospheres of oxygen in his apparatus, and there was still oxygen in the apparatus when his body was recovered.

It is reported that in addition to the exploration work done by Gilmore, while wearing apparatus, he had at various times during the night gone ahead of the fresh air without protection, endeavoring to expedite the recovery work, and he may have been near the point of exhaustion when he started on the trip in which he collapsed. Moreover, in traveling about 600 feet ahead of the air he disregarded the instructions which he had received at the fresh-air base.

The apparatus Gilmore wore was examined by a Bureau of Mines employee several days later and was found to be in good condition with the following exception: A large amount of leakage was found in the mouthpiece at the point where the metal flange is inserted in the rubber part. The rubber part had been placed upside down on the metal flange, and full dependence was placed on shellac to hold the metal and rubber pieces together to form an airtight connection. The shellac had broken so that the connection was not airtight. The recommended procedure for attaching the rubber mouthpiece to the metal flange is to apply shellac to the metal flange, insert it in the rubber mouthpiece, wrap the connection with wire, and apply adhesive tape over the wire.

The atmosphere in which Gilmore died was deficient in oxygen and contained a high percentage of carbon monoxide. It is reported that immediately before he collapsed he turned his head and motioned to the other two crew members to come ahead. When he turned his head without his body either the inhalation or exhalation tube would tend to draw on the side of the metal part of the mouthpiece and cause the loose rubber part to slip in such a way as to leave an opening through which the wearer could take a full inhalation of the deadly outside atmosphere. It is thought that the inhalation, which Gilmore took as he turned his head, contaminated to a large extent with the deadly outside atmosphere was (in his presumably weakened condition) sufficient to cause his immediate collapse.

Frank Burns, Roy Rushton, and William Heagy

On April 1, 1927, Frank Burns, Roy Rushton, and William Heagy, members of a Valley Camp Coal Co. mine rescue team, lost their lives in the No. 1 mine of the Connellsville By-Products Coal Co., Pursglove, W. V while opening a sealed fire area. The men were wearing Gibbs oxygen breathing apparatus

In sealing the fire several months before, stoppings had been erected at the portal of the main slope, and the crew, consisting of six men, entered the slope through an air lock for the purpose of erecting stoppings to form

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another fire air lock approximately 425 feet from the mouth of the slope. They did not carry a lifeline, and there was no reserve crew at the fresh-air base. (A reserve crew was available, but the men comprising this crew were permitted, by those in charge, to leave for lunch.) Burns and his crew had traveled about 225 feet when Rushton showed signs of distress and fell, whereupon, Burns, the team captain, instructed Heagy and two others to remain with Rushton while he and the other crew member returned to the surface to obtain a stretcher and additional help to carry out Rushton. Considerable time was required for Burns to assemble a relief crew on the surface; and when he and his companion, in company with the relief crew, arrived at the point where Rushton had collapsed, it was found that Heagy had also collapsed. Thinking that there was a better chance to save Heagy's life than Rushton's, he was placed on the stretcher and carried out of the mine. Another crew was then organized to go after Rushton; however, when this crew reached the bottom of the slope they found Burns down, with his mouthpiece removed, and they immediately carried him outside. Artificial respiration was applied and oxygen administered to both Heagy and Burns, but they could not be revived. The body of Rushton was not recovered until several hours later because of the demoralized condition of the crews. Finally, a fresh crew from a neighboring mine entered the air lock and recovered Rushton's body.

It is known that Burns and the members of his crew had had only a few days training in the use of oxygen breathing apparatus before starting the work in which three of them lost their lives and that they were definitely warned that they required more training before engaging in the contemplated recovery operations. It is almost certain that this loss of life would not have occurred if a well-trained crew with a properly trained and equipped reserve crew at the fresh-air base had been used.

Rush D. Hiller

On October 8, 1930, Rush D. Hiller, an undertaker of Canton, Ohio, lost his life while wearing a 1/2-hour McCaa oxygen breathing apparatus in the property of the Dalton Coal Co., Dalton, Ohio.

This accident occurred in a small slope mine in which there was no second opening. A wooden partition had been installed in the 385-foot slope to provide an intake and return airway for the mine. A fire had destroyed the surface buildings and fan near the mouth of the slope and had also destroyed the wooden brattice for about 40 feet into the slope. Three men, who were in the mine at the time of the fire, were killed by carbon monoxide from the fire.

In an effort to reach the three men who were trapped in the mine, Hiller, wearing a 1/2-hour McCaa apparatus, and one of the mine owners

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and a fireman from Massillon, Ohio, wearing gas masks, entered the slope without a lifeline or a reserve crew at the fresh-air base. No flam safety lamp to indicate oxygen deficiency, and no canary or other means of detecting carbon monoxide were carried by the rescue party. When they had gone about 150 feet down the slope, Hiller removed his mouthpiece and remarked that the air was good. He had no more than finished the remark than he collapsed. The other two men attempted to carry hi to the surface but became exhausted before they had gone very far; consequently, they left Hiller and proceeded to the surface to get help. Another man put on a gas mask, went down the slope, and tied a rope aroun Hiller. After Hiller was dragged out of the slope by men on the surface an attempt was made to resuscitate him by means of artificial respiratio and a pulmotor, but doctors on the scene pronounced him dead.

The apparatus worn by Hiller was later inspected by a representative of the Bureau of Mines and found to be in good working condition except for a hole in the inhalation tube, which appeared to have been caused by friction when Hiller and the apparatus were dragged up the slope. Hiller had purchased the oxygen breathing apparatus for his own use. He had no previous training in the use of such apparatus and probably had no knowledge of the dangers of wearing an apparatus in fire gases containing carbon monoxide.

Andrew Wolfgang

On May 16, 1940, Andrew Wolfgang, a foreman of the Philadelphia & Reading Coal & Iron Co., and captain of a mine rescue team, lost his life while wearing a McCaa 2-hour oxygen breathing apparatus, in an attempt to rescue a miner at the bottom of a 50-foot, almost vertical, shaft at a "bootleg" mining operation.

The first victim, a miner, lost his life, according to a press repor when he attempted to return to the bottom of the shaft soon after firing a shot. When he had gone only about 15 feet down the shaft ladder he was overcome and fell to the bottom.

After putting on the apparatus, Wolfgang tied a rope around his bo climbed down the 50-foot ladder to the bottom of the shaft, and attached another rope to the body of the miner. After the miner had been hoisted to the surface, Wolfgang started to climb out and when about 20 feet up s stopped for several minutes as if to rest and then started up again. He collapsed about 17 feet from the shaft collar, let go of the ladder, and would have fallen to the bottom had it not been for the rope around his bo When the men on the surface tried to pull him up it was found that the ro had fouled in the ladder, resulting in a delay of about 10 minutes in gettir him to the surface. Artificial respiration failed to revive him.

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When the body of Wolfgang reached the surface, it was found that the apparatus was intact, with both mouthpiece and nose clip in place, and with 15 minutes of oxygen remaining in the bottle. Subsequent tests disclosed that it was in good working condition. Based on the facts that Wolfgang was considerably overweight, that he had just eaten his supper when called to the scene of the accident, and that he hurried to get the apparatus up the hill to the shaft, the conclusion was reached that he died of heart failure due to overexertion and lack of physical fitness.

Reese Phillips and Gray Lacey

On October 6, 1940, Reese Phillips and Gray Lacey lost their lives while wearing Gibbs oxygen breathing apparatus after entering a sealed-fire area at the Wanamie Colliery of the Glen Alden Coal Co., Wanamie, Pa.

Phillips, Lacey, and another man, all wearing oxygen breathing apparatus, entered the sealed area to place a line of hose so that a stream of water could be directed onto a fire. On the way into the fire Phillips complained of trouble with his apparatus, and it was decided to return to the fresh-air base. After starting back Phillips collapsed, whereupon Lacey became panic-stricken and rushed toward the fresh-air base. The third man followed Lacey and tried to persuade him to return and assist Phillips to safety, but his panic increased, and he rushed past the opening leading to the outside of the sealed area, continuing along an old airway that had numerous falls and caves in it. After traveling for some distance along this old airway he climbed on top of a fall and crawled along it until he became wedged tight. When a rescue party arrived to recover his body, it was necessary to cut the apparatus straps before the body could be extracted.

The survivor stated that after trying to calm Lacey, he returned to Phillips and attempted to drag him to the fresh-air base but was unable to do so. He then returned to the fresh-air base but had to go out of the mine to get assistance. Considerable time elapsed before the bodies were recovered.

SUMMARY

The information contained herein was abstracted from disaster reports, letters, and other papers in the files of the Bureau of Mines and from annual State reports. Unfortunately, complete details were not available in all instances; however, the author has included all information that was available or thought to be of value. The following table presents, in condensed form, essential information relative to the 19 accidents, resulting in the loss of the 26 lives that are discussed. A study of the table reveals lessons that should be learned from the deaths of these men and

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LIVES LOST WHILE OXYGEN BREATHING APPARATUS WAS BEING WORN

Name of person	Date	Mine	Company	Location	Type of apparatus	Possible contributing causes of death
E. A. Sutton	February 9, 1911	Cokedale	Carbon Coal & Coke Co.	Cokedale, Colo.	Draeger 2 hour	A B C D E F I M
Joseph E. Evans 1/	April 7, 1911	Pancoast	Price Pancoast Coal Co.	Throop, Pa.	do.	A B C D E I
John Ferrell 1/	January 19, 1912	No. 2	Pittsburgh & Eastern Coal Co.	Cherry Valley, Pa.	do.	A B C D E F I
William McColligan	April 23, 1913	Cincinnati	Pittsburgh Coal Co.	Courtney, Pa.	do.	B C D E F I
Edward Evans 1/	September 30, 1913	No. 1	Union Pacific Coal Co.	Rock Springs, Wyo.	do.	E G H
James Laird	October 22, 1913	No. 2	Stag Cannon Fuel Co.	Dawson, N. M.	do.	B C D E J K
B. Poyser	do.	do.	do.	do.	do.	B C D E J K
Gomer Phillips 2/	May 24, 1915	Smokeless No. 1	Smokeless Coal Co.	Johnstown, Pa.	Fleuss 2 hour	A B C D E I
Thomas Hendrickson 3/	September 17, 1915	Quincy	Albion Mining Co.	Salt Lake City, Utah	Draeger 2 hour	A B C D E I K M
Lewis M. Jones 1/	October 20, 1916	No. 7	Jamison Coal & Coke Co.	Barrackville, W. Va.	Fleuss 2 hour	B C D E I K
Walter Kerr 1/	May 6, 1917	Hastings	Victor American Fuel Co.	Hastings, Colo.	Draeger 2 hour	B C E G I
Samuel T. McMahon	November 13, 1917	No. 7	Jamison Coal & Coke Co.	Barrackville, W. Va.	Fleuss 2 hour	A B C D E I
Bryce Warren	do.	do.	do.	do.	do.	A B C D E I
David Murphy 5/	February 26, 1918	Government	Carthage Fuel Co.	Carthage, N. M.	do.	B D E
James S. Cunningham 1/	August 25, 1919	-	Sinclair Oil & Refining Co.	Trinidad, Colo.	Salvus(1/2 hour)	A C D E
Henry DeWinter	July 10, 1920	Old No. 2 Slope	Pacific Coast Coal Co.	Black Diamond, Wash.	Draeger 2 hour	B D E H K
Hugh Hughes	do.	do.	do.	do.	do.	B D E H K
James Hudson, Jr.	do.	do.	do.	do.	Gibbs 2 hour	B C D E
Albert Gilmore	December 31, 1921	No. 1	Ellsworth Collieries Co.	Ellsworth, Pa.	do.	A B C D F I J L
Frank Burns	April 1, 1927	do.	Connellsville By-Products Coal Co.	Pursglove, W. Va.	do.	B C D M
Roy Rushton	do.	do.	do.	do.	do.	B C D M
William Heagy	do.	do.	do.	do.	do.	B C D M
Rush D. Hiller 6/	October 8, 1930	Dalton	Dalton Coal Co.	Dalton, Ohio	McCaa(1/2 hour)	A B C D I M
Andrew Wolfgang 7/	May 16, 1940	-	Anthracite ("bootleg") operation	Ashland, Pa.	McCaa 2 hour	A D G I L
Reese Phillips	October 6, 1940	Wanamie	Glen Alden Coal Co.	Wanamie, Pa.	Gibbs 2 hour	A B C D I
Gray Lacey	do.	do.	do.	do.	do.	A B C D I

1/ Employed by the Federal Bureau of Mines
2/ Employed by the Cambria Steel Co.
3/ Employed by the International Exploration Co.
4/ Employed by the Colorado Fuel and Iron Co.
5/ Employed by the Phelps-Dodge Co.
6/ Employed by himself
7/ Employed by the Philadelphia & Reading Coal & Iron Coal Co.

A - Less than 5 men on crew. B - Crew split up after distress of a member.
C - No lifeline carried by crew or crew traveled beyond lifeline.
D - No reserve crew or less than 5 men in reserve crew at fresh-air base.
E - Faulty design or nonpermissible-type apparatus. F - Defective apparatus.
G - Defective physical condition of wearer.
H - Training or maneuvers conducted in dangerous atmosphere.
I - No physical examination previous to entering the mine.
J - Disobedience of instructions. K - Traveled too far ahead of fresh-air base.
L - Fatigue previous to wearing of apparatus.
M - No training or insufficient training in wearing apparatus.

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emphasizes clearly the precautions that must be taken if similar accidents are to be avoided in future.

The table also shows that lives were lost while oxygen breathing apparatus was being worn on 19 different occasions, as follows:

On 12 occasions the crew consisted of less than five men (four one-man crews, three two-men crews, two three-men crews, and three four-men crews.)

On 16 occasions the crew split up following the distress of a crew member or members. (In some instances this was necessary because of insufficient oxygen supply.)

On 13 occasions the crew did not have a lifeline or went beyond the lifeline.

On 18 occasions there was no fully equipped reserve crew, of at least 5 men, at the fresh-air base.

On 3 occasions the crews traveled too far ahead of fresh air.

On 2 occasions the crews were engaged in training or maneuvers.

On 1 occasion work was being done in a partly empty gasoline tank containing gasoline vapors.

On 1 occasion three men and on 4 occasions two men of the same crew lost their lives.

On 13 occasions (perhaps others) no physical examination was made of the crew members before they entered the mine.

On 2 occasions the crew disobeyed instructions.

The table shows details relative to the 26 lives lost as follows:

Five men (19.23 percent) were employees of the Bureau of Mines.

Five men were employees of other companies and one man was employed by himself.

Eighteen men were wearing nonpermissible apparatus.

Four men were wearing defective apparatus.

Two men were found to have physical defects (bad heart).

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Two men were probably fatigued before wearing apparatus.

Six men definitely had insufficient training before wearing apparatus during rescue and recovery work.

Eleven men were wearing Draeger, 7 - Gibbs, 5 - Fleuss, 1 - McCa 2-hour, 1 - Salvus 1/2-hour, and 1 - McCaa 1/2-hour apparatus.

Nineteen men lost their lives from 1911 to 1921 inclusive, and seve from 1922 to 1940 inclusive. No lives were lost during 1914, 1922 to 192 inclusive, 1928, 1929, 1931 to 1939 inclusive, and 1941 to 1943 inclusive.

LESSONS TO BE LEARNED

The death of 26 men wearing oxygen breathing apparatus has lead to some conclusions that have been advantageous in preventing similar accidents and should be helpful in preventing loss of life in the future. It is hoped that all persons who have charge of rescue and recovery oper ations after mine fires and explosions and all who may wear oxygen brea ing apparatus will read carefully the examples cited in this paper and wi observe the lessons that have come from these disasters; the most important are the following:

1. Explorations or other work ahead of fresh air should not be attempted with a crew of less than five men.

2. Members of a crew should not separate from other crew mem while ahead of fresh air unless it is absolutely necessary to do so.

3. A lifeline or other means of communication with the fresh-air base should always be carried by a crew while exploring or working ahead of fresh air.

4. A fully equipped reserve crew of not less than five men should kept in readiness at all times at the fresh-air base while exploration or other work is in progress ahead of fresh air.

5. Apparatus should be thoroughly tested immediately before bein used in a dangerous atmosphere.

6. Apparatus men should be given a thorough physical examinatio by a physician before being considered qualified to wear oxygen breathi apparatus. They should also be reexamined by a physician shortly befo wearing apparatus at a mine fire or explosion.

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7. The team captain should follow, as nearly as possible, the instructions given him by the responsible official at the fresh-air base.

8. Crew members should obey their captain at all times while working in advance of fresh air, regardless of circumstances.

9. The length of trips made while wearing oxygen breathing apparatus should be limited to not more than 1,000 feet when the way is clear except in extreme emergencies where life is involved. When there are falls, bodies of water or other obstructions, and on steep grades and pitches, the length of travel should be proportionate to the difficulty of travel.

10. No person should be considered qualified to wear oxygen breathing apparatus at a mine fire or explosion unless he has taken the Bureau of Mines standard course or its equivalent, or has received additional training in mine rescue work within 12 months.

11. The crew should be trained fully in the procedure to follow if a crew member is in distress or collapses.

12. A crew traveling or working ahead of fresh air should carry a stretcher at all times.

13. When one or more members of a crew shows signs of distress, a prearranged signal should be given immediately to the fresh-air base, and the crew should start to retreat toward the fresh-air base leading the distressed member or carrying him on a stretcher, as the case may require.

14. Upon receipt of a distress signal, the reserve crew should proceed immediately toward the crew in distress, and upon meeting it should assume the burden of the distressed member or members.

15. Communication between team members should be accomplished by means of signals, and no attempt should be made to speak while oxygen breathing apparatus is being worn in irrespirable atmospheres.

16. Mine rescue crews should be trained as units and substitutions should not be made unless absolutely necessary.

17. Apparatus men should not eat a heavy meal immediately before wearing apparatus.

18. Apparatus crews should be fully rested before attempting to do work or explore ahead of fresh air.

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19. Apparatus men should not breathe air containing carbon monoxide or other toxic gases before wearing breathing apparatus ahead of the air.

20. Apparatus-crew members should be required to have a practic knowledge of mine gases and to have had practical underground mining experience.

21. Apparatus men should not enter tanks or other openings alone unless fitted with a safety belt having a rope leading to fresh air. There should be enough men at the fresh-air opening to be able to pull the dead weight of the man and the apparatus to the opening.

CONCLUSIONS

In all cases, except one, where men lost their lives while wearing oxygen breathing apparatus, the work was not conducted in accordance with present recognized requirements, and in the excepted case the man had a serious heart defect. Under the conditions prevailing, it is surprising that additional lives were not lost in several instances.

The safe use of oxygen breathing apparatus depends on carefully selected, well-trained men wearing apparatus of approved design that is in good condition; a proper organization under the direction of a competent man or men; and strict adherence to sound, safe procedure. If th essential requirements are followed rigidly few, if any, lives will be los as the result of wearing such apparatus. On the other hand, if they are neglected serious consequences are almost certain to follow.

That oxygen breathing apparatus can be worn with safety is shown by the many instances where such apparatus has been used successfully Rescue and recovery work after mine fires and explosions, involving the wearing of oxygen breathing apparatus by crews of five or six men each for periods of from several hours to continuous operation for several months, has been successfully done with little or no difficulty experienc by the men wearing the apparatus. This conclusively proves that such apparatus can be safely worn when proper precautions are exercised in conducting the work.

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